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NOTES ON THE EARLY STAGES OF CHRYSOPS (DIPTERA, TABANIDÆ).[1]

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Of the 34 species of chrysops known to occur in the state of New Jersey, 11 were found in Princeton; these were the following species:[2]

1. *Chrysops niger* Macq. Basin, July 4, 5.
2. *Chrysops obsoletus* Wied. Greenhouse near Guyot Hall, July 8, 12; August 26.
3. *Chrysops fallax* O. S. Genetics Garden, July 6, 8.
4. *Chrysops callidus* O. S. Very common. Pond near Guyot Hall; greenhouse; Lake Carnegie; Plainsboro, June; July 4, 6, 8, 14, 15, 20.
5. *Chrysops hinei* Daecke. Near Guyot Hall, July 4.
6. *Chrysops univittatus* Macq. Carnegie Lake; Plainsboro, July 7, 8, 14, 20, 23.
7. *Chrysops lugens* v. *morosus* Wied. Basin; Genetics Garden; June 30; July 8.
8. *Chrysops montanus* O. S. Genetics Garden, July 6, 15.
9. *Chrysops striatus* Wied. Princeton, July 8; August 20, 23.
10. *Chrysops vittatus* Wied. Genetics Garden, July 25.
11. *Chrysops mœchus* O. S. Princeton, July 4.

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[2] To these, *Chrysops uter* O. S. has to be added, which is quite common, but was overlooked in 1915, as its time of appearance does not extent July.

All the adult specimens obtained were ♀♀, except the one and only specimen of *C. mœchus,* which was a ♂. The individuals were collected partly while attacking the collector, partly from windows of the greenhouse, Guyot Hall and the vivarium of Princeton University, partly in the act of egg-laying and on flowers and bushes. One female *C. callidus* was taken in the evening of July 14 on a flower of milkweed (*Asclepias*).

The species were identified with the aid of the collections deposited in the New Brunswick Agricultural Experiment Station and the Academy of Science in Philadelphia. The writer here takes the occasion to thank Dr. Thomas Headlee, of New Brunswick, and Messrs. E. T. Cresson and Dr. Henry Skinner, of Philadelphia, for their help. For material, I am indebted to Dr. Theobald Smith for specimens of *Chrysops* from New Hampshire, and to Mr. Macy, who was in charge of the Guyot Hall greenhouse, and who collected considerable numbers of the flies. Others were collected by boys.

The Egg-laying Habits of Chrysops.

Hart (1895) has described the egg-laying habits of *Chrysops mœrens* Walker (syn. *œstuans* Meigen). Hine (1903) describes the egg-laying habits of *C. callidus* O. S. Part of these observations have been duplicated by the writer, since at the time when the observations were made the literature was not at hand, but as our knowledge in general is still very incomplete, the following notes may add some detail to the results previously recorded.

Observations could be made on *Chrysops callidus* and one other species of *Chrysops,* which could not be fully determined, since only the eggs were found, and no specimen was caught in the act of laying. This species was probably *C. univittatus.* It is of interest that the appearance of the egg-cluster in this species is very different from that in *C. callidus* and the other species observed.

Chrysops callidus is found ovipositing near ponds and streams on semi-aquatic weeds, chiefly in the morning hours till after 11 o'clock, from the latter part of May to the end of July. In oviposition, the females alight on a leaf or reed, head pointing downward, and proceed to lay while moving slowly in a downward direction (Plate X, fig. 1). The eggs are laid in a cohesive mass or cluster, usually on

the under side, seldom on the upper side of leaves, a difference which is not marked in the case of vertically growing plants, such as *Typha, Sparganium,* etc. They are usually found at a height of 6 inches to 2 feet above the surface of the water, never on plants which grow any great distance from the water. It seems that in the choice of its laying-place the female is somehow attracted by the sight of the reflecting water-surface.

The plants on which the eggs are found deposited are of a great variety, including *Pontederia cordata, Nuphar* spec., *Peltandra* (*Aroideæ*), *Typha latifolia* and *angustifolia, Acorus calamus,* various *Gramineæ, Polygonaceæ* and *Equisetum* sp. No special preference was shown for any of these, except that where *Typha* was most abundant the eggs were nearly all found on *Typha*; while where *Pontederia* was common there seemed to be more egg-masses on *Pontederia* than on any other plant. Most of the egg-masses seen in the field certainly belonged to *C. callidus,* but it is not impossible that some, while not differing in appearance, may belong to other species of *Chrysops.* The *Chrysops* egg-masses were never found on wood or on stones; the species show a decided preference for laying on plants. The egg-laying instinct is, therefore, apparently determined by two factors: the presence of water and the presence of plants growing above its surface. The egg-masses appear much less numerous in places like Plainsboro, where considerable areas are of a swampy character, evidently because the conditions for oviposition are here evenly distributed. In places, however, where the swamp-vegetation has been artificially removed, as in the case of Lake Carnegie and of the little pond near Guyot Hall (Princeton University grounds), the plant growth is developed only at the edges and it is on these alone that the conditions for oviposition are found. This, perhaps, accounts for the large numbers in which the *Chrysops* are ovipositing here and this phenomenon provides a favorable opportunity for the study of their life-history.

The time of oviposition is, in *Chrysops callidus,* the morning, from 8 to 12 o'clock; and the largest number is found ovipositing between 10 and 11 o'clock. Only very exceptionally I found *C. callidus* ovipositing at 4 o'clock in the afternoon. The habit of laying in the forenoon differentiates it sharply from the other species observed which lay in the late afternoon. The eggs are creamy white at first,

and fresh egg-masses are easily recognized by their color, but in the course of a few hours the color changes first to gray then to shining black, and the majority of the egg-masses found are of this color.

The egg-masses or egg-clusters in *Chrysops callidus* are elongate in shape and much flattened, tapering at both ends, especially so at the upper end; the lower half may be abruptly truncate. Each cluster consists of a single layer of eggs (as Hart has previously stated), which are regularly arranged in oblique rows: their whole arrangement being like that of shingles on a roof, with the difference that the lower eggs overlap the upper ones to about three quarters of their length; hence the arrangement is precisely the opposite of what one should expect if the intention were to prevent rain water from penetrating between the eggs. However, the whole mass, especially when a few days old, presents an almost perfectly even surface, and full protection against moisture is afforded by a thin shining outer layer or membrane, which seems to be a secretion of the eggs themselves covering the whole mass soon after oviposition is completed. It is only after piercing this membrane that individual eggs can be removed from the cluster. (See plate X, fig. 2, which, however, represents an egg-cluster of a somewhat irregular shape.)

The egg-cluster may contain from 250–300 eggs (actual counts gave 277 in one case, 260 in another). The single egg (Plate X, fig. 3), is spindle-shaped, tapering at both ends, but more so at the hind end, by which it is attached to the surface. After oviposition, it is at first semitransparent, and contains, in its upper third, an opaque whitish mass, apparently yolk. This yolk chiefly determines the whitish appearance of the cluster.

The arrangement of the eggs in the cluster is, of course, the result of the special manner in which the eggs are deposited by the female.

In the act of laying, the adult fly sits, as stated, always head downwards on the stem or leaf of the plant selected, and begins, after repeatedly trying out various places, by placing one egg about in the middle of the leaf (*Typha*); it then places a second egg on the side of this, but a little farther down. Evidently the fly first touches the first laid egg with the tip of the abdomen, and then moves the abdomen slightly downwards, by a movement which depends on or is determined by the resistance found in touching the first-laid egg.

The fly then proceeds to lay, beginning from the outer edges of the egg-cluster obliquely downwards towards the lower end. Having reached this, the abdomen finds no resistance to its movements, hence it is withdrawn upwards, and a new series of eggs is laid parallel to the former, or, more frequently, the abdomen is shifted to the other side of the cluster, and here the following row is laid. Sometimes the fly alternates regularly between the right and left side of the cluster, sometimes she may lay two or three rows of eggs on one side, ending near the middle of the cluster at the lower extremity. During oviposition, the female fly is rather quiet, and a leaf or stem may be taken from the field to the laboratory together with the egg-laying fly, as Hine has already stated. After about three quarters of an hour the egg-mass is completed, and the fly darts off suddenly. If disturbed, however, the flies often leave in the middle of the act of oviposition. An egg-mass once abandoned is never completed, as the fly does not return to the same leaf, and evidently has no means for finding her egg-mass again, and no instinct of looking for it. Flies which in a glass jar in the laboratory had continued to lay never started laying again if they once had been disturbed and caused to leave their egg-clusters, but acted like other captive *Chrysops,* which I could never induce to deposit any eggs.

In one case only, a female, having been disturbed in the occupation of laying, and having paused for a few minutes, started again with movements of the abdomen, evidently in the intention to continue laying. However, having changed its position on the leaf but slightly, it could not reach the egg-mass any more with the tip of the abdomen; and after continuing for awhile to press the abdomen against various places on the leaf, as if in search for the egg-mass, it gave up and left. Apparently for each female it takes a long preparation until a suitable place to lay the first egg is found, while to continue the egg-laying act the presence of previously laid eggs is necessary.

Since many females of *Chrysops,* in nature, leave the egg-mass before it is completed, many of the clusters have only their upper half complete, while the lower half ends more or less obliquely truncarte or "diamond-shaped" (Hine).

I have described the eggs of *Chrysops callidus* above, and recall that the white coloration of the fresh egg-clusters is due to the pres-

ence of yolk in the upper half of the otherwise semi-transparent egg. However, soon after oviposition is terminated the color of the eggs begins to change and to turn into a mottled grey, thence to shining black. This process can be easily watched under a strong lens. It is seen that the black color appears at first in the upper half of the egg on that side which corresponds to the dorsal side of the embryo and in the shape of a symmetrical spot with several branches reaching backward about to the middle of the egg (Plate X, fig. 6). In this stage the beginnings of the embryonic development may be seen in the lower part of the egg. In about two to three hours, often sooner for in one instance only one hour was required, the entire egg has turned black. In *Chrysops callidus,* therefore, it is not possible to make any direct observations upon embryonic development. The eggs of another species which I found remain transparent and afford an excellent object for such observations.

The duration of embryonic development until hatching, is, in *C. callidus,* about five days. Eggs laid on July 6, 1916, at 11 A. M., were found hatched on July 11, at 12 o'clock, but had probably hatched in the preceding night or early in the morning. Eggs laid on July 20, at 3:30 P. M., were found hatched on July 25, at 11 P. M.

The time of hatching is almost invariably in the evening soon after sunset or later. Times of hatching recorded were 7:10 P. M., 8 P. M., on July 6, 1915; 9 P. M. on July 12; 11:20 P. M. on July 25; 8:30 A. M. on July 13; and between 11 P. M. and 9 A. M. on August 7–8. In one case at least the larvæ were observed to hatch in the morning, at 8:30. Although watched, none were seen hatching during daytime.

The act of hatching itself is not without interest. In most cases all the larvæ hatch at about the same time, each one leaving the egg through its upper pole, and the black surface of the clusters is suddenly seen covered with a whitish wriggling mass. A number of single larvæ may hatch somewhat later and the whole process may take a quarter of an hour. The larvæ are very active and decidedly thigmotactic, clinging to each other and forming masses or lumps, which soon loose their hold on the smooth surface of the cluster and drop to the ground or, under normal conditions, into the water.

It was found that it is absolutely vital for the young larvæ to reach water soon after hatching. Larvæ which were allowed to drop

on a sheet of paper would crawl about for a short while, but an hour later all had died. Efforts to bring them back to life by placing them in water proved fruitless.

Reaching the water under normal conditions, the *Chrysops* larvæ at once sink to the bottom; the lumps are dissolved and each larva moves about with a slow wriggling movement. The young larvæ measure about 1 mm. in length. They are at first positively phototropic, and the majority of them congregate on that side of the jar which is turned towards the light. This tropism is reversed after the first molt and it is evidently then that the larvæ burrow into the mud, where they seem to spend the rest of their life until pupation.

DESCRIPTION OF THE LARVA OF C. CALLIDUS.

The young larvæ were placed in small glass jars with a small quantity of mud and aquatic plants. Young crushed dragonfly and Chironomus larvæ were given as food. Their growth, however, was very slow and I did not succeed in keeping them alive much longer than after the first molt. This was partly due to the difficulty of furnishing them a suitable food supply and at the same time keeping the water pure and rich in oxygen, as the pretence of decaying material seems fatal. I will, however, give here a description of the young larvæ, as they have never been described in any species of *Chrysops*. Concerning the larval stages of this genus, we had up to very recently only the description of the full-grown larva of *Chrysops vittatus,* by C. W. Hart (1895). It will be seen that even the very young larvæ of *Chrysops* show very marked peculiarities which permit us to differentiate them from young larvæ of *Tabanus,* at least those which I had under observation.

All Tabanid larvæ are, as we know well, comparatively uniform in structure, hence repetition in description is to some extent inevitable. The young larvæ of *Chrysops callidus* are about 1 mm. in length, elongate, tapering at both ends, with tracheæ not yet filled with air and prolegs not exserted, consequently presenting a more or less even surface. Their color is grayish white (Plate X, fig. 4). The body has twelve segments, the head is small, pointed, blackish brown in color and highly chitinized. The prolegs or parapodia are visible as small knobs on the fourth, fifth, sixth, seventh, eighth, ninth, and

tenth segments, two pairs on each of these segments, forming two pairs of rows, one lateral and one ventral. On the dorsal side of the second segment a pair of black ocelli are visible which in reality lie not on the upper surface of this segment but underneath it on the upper side of the pharynx which, with the head and mouth, is retractile. The eyes are moved forwards and backwards with the pharynx, so as to lie apparently sometimes in the second and sometimes in the third segment of the body. Similarly located at the hind end of the body and situated on the dorsal side of the tenth or eleventh segment lies the "organ of Graber," to be spoken of later, visible as two small black dots. The twelfth segment is terminated obtusely in the newly hatched larva (Plate X, fig. 4).

First Molt.—Only a few hours after hatching the larvæ, placed in water, begin to molt. The act of molting was observed repeatedly and the presence of larval skins in the water indicates that it has taken place. Plate X, fig. 5, shows an individual in the act of molting. This first molt has not been noticed in Tabanid larvæ, nor by Mitzmain, who has given some attention to the subject of molts.

Description of Larva After First Molt.—After the first molt the larvæ are more slender and slightly longer than before. The prolegs are now more in evidence, protruding at right angles from the body-surface, and the crawling movements become much more energetic (Plate X, figs. 7 and 8). In the structure of the head no important changes could be noticed; of these structures and of the mouth parts and antennæ, a more detailed illustration is given (Plate XI, fig. 3). Hart gives as difference between *Chrysops* and *Tabanus* larvæ the relative length of the last and second-to-the-last antennal joints; this character could so far not be verified with certainty in this young stage. A very good character which seems to separate at least those *Chrysops* and *Tabanus* larvæ which I had under observation is found in the tracheation. The main tracheal trunks of the young larva of *C. callidus* are relatively slender and narrow, being between one eighth or one tenth of the abdominal diameter in width, while in the young *Tabanus* larva the tracheal trunks are of much wider diameter. In the *Chrysops* larva, the diameter of the main tracheal trunks remains the same throughout their entire length, while in *Tabanus* they are much more inflated in the posterior half of the body than in the anterior (Plate XI, figs. 1 and 2).

The tracheæ are dark or shining silvery-white, according to the light, and are filled with air. The two main stems converge towards the end of the body, where they terminate in a sharp acuminate tail (fig. 8).

Description Summarized.—Body spindle-shaped, 12-segmented, slightly above 1 mm. in length; general color grayish white, semi-transparent. Head retractile; mouth parts small, dark brownish, chitinized; eyes situated on pharynx, black. Last segment ending in an acuminate tail, on the base of which are two bristles on each side. Segments 4–10 with two pairs of ventral and two pairs of lateral prolegs; the latter armed with short stiff bristles pointing backward (Plate XI, fig. 5). Intestine straight, except in the middle region of the body. Main tracheal trunks parallel in the posterior half of the body, while in the anterior half forming two large semicircular loops, ending in the region of the fourth segment, and here dividing up into small tracheæ. Chitinous surface striated as seen in Plate XI, figs. 4 and 5, Graber's organ consisting of a capsule containing only one pair of black pedunculate bodies.

Movements of the Larva.—These are carried out in the following way: the larva presses the prolegs against the surface on which it moves, then drives the main mass of the body through them by means of contractions in the posterior half of the body, while the intestine is protruded forwards and the head exserted. Then the prolegs abandon their attachment, and seem to be moved forward by the elasticity of the body to which they are attached.

Activities of the Larvæ.—The larvæ were kept in small dishes with water and some aquatic plants. In water without special care they perished in less than a week; when fed and taken care of, they lived slightly longer. As food, crushed dragonfly larvæ, mosquito larvæ, crushed small caterpillars were given and accepted. However, their numbers always rapidly diminished. This is partly accounted for by their cannibalistic tendencies. Mitzmain states that larvæ of *Tabanus striatus,* even if other food was offered, preferred their own kind to any other food given. Another difficulty was to keep the water in small jars free from putrefaction. For this purpose green plants (*Elodea, Myriophyllum*) were given, but these plants decayed, and the larvæ perished. Mud seems necessary for the larvæ to burrow into, but renders their observation impossible. With a proper method,

however, it should not be difficult to raise *Chrysops* larvæ, and a new attempt will be made in the coming season.

Chrysops spec.—On July 7, 1916, 6 P. M., a *Chrysops* was seen ovipositing on the under side of a leaf of *Nuphar* (yellow pond-lily), the leaves of which often protrude above the surface of the water, on the north shore of Carnegie Lake, near the Princeton University boat-house. Unfortunately the specimen escaped, but it was undoubtedly a *Chrysops* of rather dark appearance, probably either *C. univittatus,* which is dark and next most common to *C. callidus,* or *C. lugens* v. *morosus,* or possibly *C. niger.* Specimens caught near this place belonged to *C. univittatus.* The egg-mass was collected and was very different in appearance from that of *C. callidus.* On careful search five such egg-masses were found, four on the under side of *Nuphar* leaves, one on the under side of a *pontederia* leaf nearby. As eggs of this kind were found nowhere else, it seems that the species has a predilection not only for *Nuphar* but also for the particular spot where these eggs were found.

The egg-clusters (Plate XII, figs. 1 and 2) differ from those of *Chrysops callidus* and the other species in which the oviposition has been described by the arrangement of the eggs, which are elongate as in the other species but placed with the hind end almost at right angle on the leaf-surface, one close to the other, so as to form a sort of elevated layer, the vertical thickness of which corresponds to the length of the eggs and the even surface of which is formed by the anterior ends of the eggs. The whole cluster is roundish or ovoid in outline, the sides almost right-angled, formed by the rows of eggs placed one beside the other. One of the clusters was found, by actual count, to consist of 352 eggs. The color of the freshly laid one was white, as well as in two of the others when they were found, while in the two remaining it was pale brownish. On the following day the three white egg-clusters had also assumed a brownish color, a proof that they had been freshly deposited when found. It results therefore that this species of *Chrysops* differs from *C. callidus* not only in the way the eggs are deposited and their color, but also in the time of oviposition which in this species is the early evening, before sunset.

Owing to the lack of the dark pigment which obscures the development of the eggs in *C. callidus,* in this species developmental changes may be readily observed.

Each single egg is elongate as usual in *Chrysops,* and slightly curved. It was seen that the concave side of all the eggs was turned in the same direction, that is, towards the edge of the leaf on which the cluster was found. The concave side of the egg corresponds to the ventral side of the embryo. Assuming the fly sits head-downwards while laying, that is, looking towards the base of the leaf and away from its edge, each egg is deposited in such a way that on leaving the body, the ventral surface of each egg is turned backward from the fly. On the other hand, as each egg is fastened to the leaf by its tail end, one should assume that the head-end is the last to leave the body of the fly. In this way the relative orientation of mother animal and embryo could be determined, but the material was insufficient to fully ascertain this relation.

Every single egg is seen to be somewhat shrunken on its upper pole, and its outer membrane is here contracted in three ridges meeting at the tip at about equal angles of 60°.

On the earliest stages of the development of the eggs I have no data, as the eggs were not examined before July 9, at noon, when they were almost two days old. Plate XII, figs. 3, 4, and 5, show the eggs at this stage. The embryo is plainly visible, occupying only about five sixths of the whole length of the egg, leaving the upper one sixth empty. The entoderm is plainly differentiated. A large mass of yolk covers the greater part of the dorsal side. Headwards on the sides are dark areas probably corresponding to the eyes which have however not yet appeared.

On the following day, July 10, at 11 P. M., these eggs were inspected again. The yolk mass had been considerably reduced, still reaching to the posterior end of the egg, and still taking almost two thirds of the entire length. Head and pharynx have become differentiated. The eyes have appeared as two black spots on the dorsal side of the pharynx. The anterior region of the embryo has been pushed forward, and the empty portion of the egg is now less than one tenth of its entire length (Plate XII, fig. 6). When an egg is lesioned at this stage, the yolk flows out immediately as it seems to be quite liquid.

The body segments are not yet distinctly visible.

On the following day, July 11, at 5:30 P. M., the larva is seen to fill the whole space afforded inside the egg-shell. At this stage, that

is, when the embryo is exactly four days old, the final body segments begin to be visible chiefly in the anterior part of the body, and the head and pharynx is seen to be in the retracted condition, while the first body segment reaches to the anterior end of the egg. Pharynx and intestine have become more distinct; the yolk mass has shrunk further, occupying now less than one half of the whole length, and not reaching the end of the body. The tracheæ and the organ of Graber are not yet visible in this individual (Plate XII, fig. 7). However, in a second individual from the same egg-cluster, the organ of Graber is seen already fully developed and also the tracheæ are discernible (Plate XII, fig. 8). The head is seen retracted as in the first-studied individual. Concerning the organ of Graber, it should be noted that if this organ really corresponds to a pair of modified hairs, as assumed by G. Paoli, it should always be simple in the embryo, as it is in fact in *Chrysops*. However, it seems that in the young *Tabanus* conditions are somewhat different. The body segments in the larva (Plate XII, fig. 8) are seen fully marked; the hind end of the body is slightly longer than the space afforded to it, and the last segment is curved in order to find room in the egg. All through these stages we notice a gradual increase in length of the whole embryo in the egg-shell, with the result that even with head retracted within the first segments, and with tail curved backward, it fills the whole available space. This may be of considerable importance in the act of hatching from the egg, as it enables the embryo to burst the egg-shell by simply stretching its body. On Plate XII, figs. 11 and 12, these movements are illustrated.

On the following day, July 12, 4 P. M., the eggs had not yet hatched. However, if the eggs are placed on a slide, a slight pressure of the coverglass is sufficient to cause them to leave the egg with vigorous movements. The young larva (Plate XII, fig. 9) is seen to be a typical *Chrysops* larva, eleven-segmented, with seven pairs of lateral prolegs which are not yet protruded, with two slender tracheal trunks forming loops in the anterior part of the body. The head is retracted and remains so in the larvæ which were caused to hatch prematurely. The yolk mass is still present but takes less than one third of the whole body length. The lower part of the intestine shows irregular windings similar to those seen in *C. callidus*. The organ of Graber is distinctly seen immediately behind the dorsal bloodvessel,

but not connected with it (Plate XII, fig. 10); the space containing the two pedunculate bodies[1] seems to be surrounded by a double capsule.

This egg-cluster perished in consequence of having been placed in too damp conditions, which caused the leaf to which it was attached, to disintegrate. The leaves of *Nuphar* decomposes with great rapididty when detached from the plant.

However, eggs from another cluster of the same species were found hatched on July 9, at 11 A. M. The larvæ were positively phototropic, and much like those of *C. callidus*. They were kept alive for one week in a Petri dish with *Ceratophyllum* and crushed *Agrion* larvæ, but after this period all died.

A third type of egg-cluster was found several times on leaves of *Sagittaria* and *Nuphar*, and of which I can not say whether it belongs to a *Chrysops* or a very small species of *Tabanus*. These egg-clusters are obliquely conical, brown in color; the eggs of which they consist, are elongate as in the other species.[2] Larvæ which hatched from one of these clusters had more the appearance of *Chrysops* than of *Tabanus*, this (1) because of their small size, (2) because of the tracheæ being narrow as in *Chrysops callidus* and the other species spoken of. They were evidently aquatic but perished within a few days.

EXPLANATION OF FIGURES.

PLATE X.

Fig. 1. Female of *Chrysops callidus* O. S., ovipositing on a leaf of *Typha*. Drawn from life.

Fig. 2. Egg-cluster of *Chrysops callidus*, somewhat abnormally shaped.

Fig. 3. Single egg of the same species. Upper half white (tip translucent), lower half transparent.

Fig. 4. Newly-hatched larva of *Chrysops callidus*. Prolegs still retracted.

[1] It has not been ascertained whether these bodies were pedunculate or not, as the organ of Graber was not known to me then, and no descriptions were at hand. I use here the term "pedunculate bodies" as used by the authors on the subject, for the black bodies readily seen in the capsule which in *Tabanus* have been shown to be "pedunculate."

[2] I notice in this connection J. S. Hine's statement that the egg-masses of *Chrysops celer* consist of several layers of eggs, being brownish in color. Presumably, then, the egg-masses spoken of belong to *C. celer* or to a related species.

Fig. 5. Young larva of same species, in first molt. Drawn from life.

Fig. 6. Egg of *Chrysops callidus,* a few hours after oviposition, showing pigment developing symmetrically.

Fig. 7. Larva of *Chrysops callidus* after first molt. Ventral side, showing ventral and lateral prolegs.

Fig. 8. Same larva (slightly more extended). Dorsal side, showing tracheal trunks and Graber's organ.

PLATE XI.

Figs. 1 and 2. Young larvæ of *Chrysops callidus* and *Tabanus atratus,* to illustrate the difference in the tracheal system.

Fig. 3. Head and first segment of young larva of *Chrysops callidus,* magnified. Note the long terminal joint of the antennæ. The first joint, which is very short, was not noticed when the drawing was made.

Fig. 4. Posterior end of newly-molted larva. Dorsal view. Graber's organ, *sk.,* shed skin, still adhering.

Fig. 5. Posterior end of newly-molted larva. Ventral view, showing anus, stigmatal spine and bristles.

PLATE XII.

Fig. 1. Egg-mass of *Chrysops* spec. on underside of *Nuphar* leaf (turned upside down). Lateral view.

Fig. 2. Same egg-mass seen from above.

Figs. 3, 4 and 5. Dorsal, lateral and ventral view of two-day-old egg of *Chrysops* spec. Note the empty space above the embryo.

Fig. 6. Egg and embryo of the same species, three days old. The eyes have appeared. The yolk is diminished in quantity.

Fig. 7. Egg with embryo of same species, four days old.

Fig. 8. Egg from same egg-cluster, four days old, but developed a little farther. Body segments and Graber's organ developed.

Fig. 9. Newly-hatched larva of *Chrysops* spec. Head retracted and prolegs not yet exserted.

Fig. 10. Graber's organ and posterior part of dorsal vessel of same larva, magnified.

Figs. 11 and 12. Movements of the posterior part of the body of the larva before hatching.

LITERATURE ON EARLY STAGES OF CHRYSOPS.

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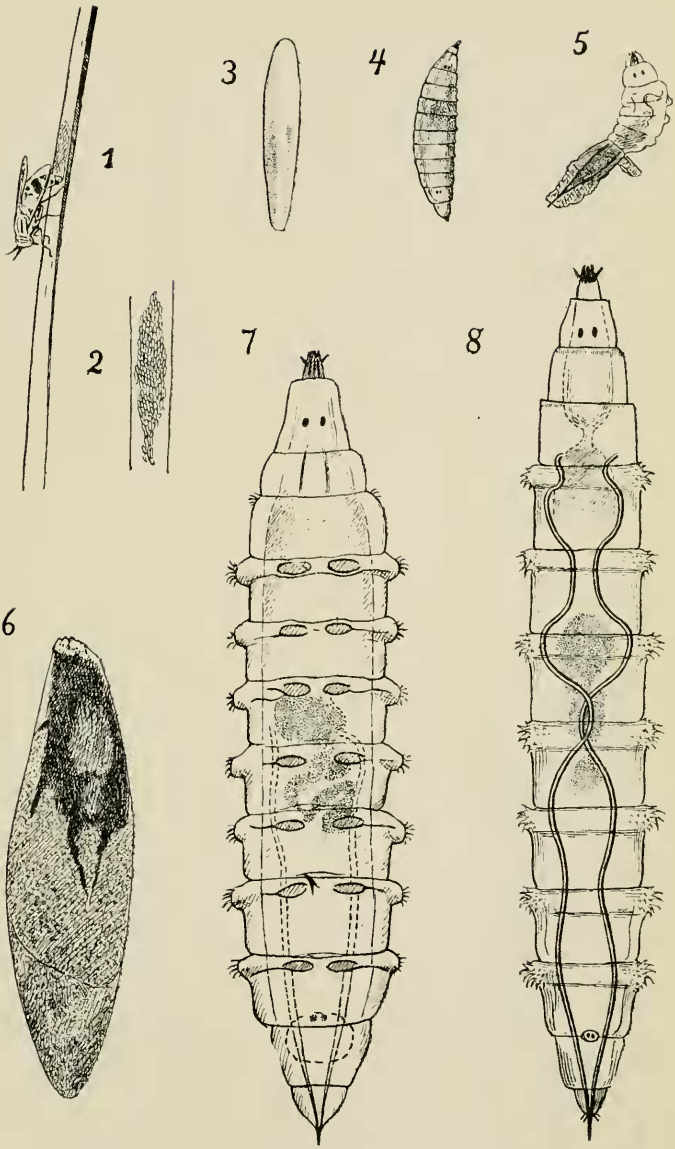

Chrysops.